Observations of scavenging carnivory by the common brushtail possum *Trichosurus vulpecula* on macropod carcasses in Namadgi National Park, montane Southeastern Australia

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Key words: *Trichosurus vulpecula*, dietary ecology, scavenging carnivory.

Introduction

The common brushtail possum *Trichosurus vulpecula* is an adaptable and ecologically variable 1.5 to 4.5 kg phalangerid possum with a very wide distribution stretching across much of the Australian continent from the tropical far north to temperate Tasmania (How and Kerle 1995; Kerle 2001). In addition to the autochthonous Australian populations, the possum now also has an almost ubiquitous presence in New Zealand following mid 19th century introduction to establish a fur industry (Cowan 1990, 2005; Montague 2000; Heinsohn 2004). Though the bulk of its diet is typically comprised of foliage, supplemented by flowers, fruit, other non-foliar plant matter and fungi (Cowan 1990, 2005; How and Kerle 1995; Kerle 2001; Heinsohn T., unpublished data), studies in New Zealand and Australia have revealed that *T. vulpecula* is flexible in its feeding behaviour and may opportunistically consume considerable quantities of both invertebrate and vertebrate animal matter (Kerle 1984; Cowan and Moeed 1987; Cowan 1990, 2005; Nugent *et al.* 2000).

Regarding the consumption of vertebrate matter, in addition to sometimes actively preying on eggs, chicks and adult birds (Morgan 1981; Sadleir 2000), in New Zealand, *T. vulpecula* has also been observed to scavenge on the carcasses of mutton birds, other possums, pigs and deer (Nugent *et al.* 2000; Cowan 2005). Some of the New Zealand observations of scavenging on vertebrate carcasses have involved apparently starving possums in poor condition (Nugent *et al.* 2000), and thus could be interpreted as aberrations due to overpopulation and stress in an introduced species. However, scavenging carnivory has also been routinely observed in apparently healthy animals within the New Zealand context, such as possums in good condition that are regularly caught in leg-hold traps baited with rabbit meat to catch ferrets (Caley 1998; Nugent *et al.* 2000; Cowan 2005). Detailed below are some recent observations of scavenging carnivory by *T. vulpecula* on large mammal carcasses within an Australian context.

Study area, methods and results

Between 2002 and 2004, we observed two instances of scavenging carnivory by the common brushtail possum on large macropod carcasses in montane Southeastern Australia (Table 1). The observations were opportunistic, having been made by the authors during regular drives at night along the Boboyan Road through mixed montane Eucalyptus woodland in Namadgi National Park, ACT. Observations were made either within the headlight illumination of a strategically parked vehicle and/or with a 6V hand-held spotlight. All observations were made within the far southern section of Namadgi National Park that escaped the intense bushfires of January 2003, and one observation was made prior to that event. The results are thus not considered to have been influenced by post-fire starvation.

Discussion

Our observations within a native Australian context suggest that, rather than being an aberration, opportunistic scavenging carnivory may be a natural aspect of the possum's wide and variable dietary niche. Alternatively, isolated observations of the exploitation of large mammal carcasses may be a localised adaptation by some possums that have only comparatively recently learned to exploit the abundance of road-killed carcasses provided by an ever-expanding network of roads and increasing vehicular traffic.

Table 1. Opportunistic observations of scavenging carnivory on large macropod carcasses by common brushtail possums *Trichosurus vulpecula* in Namadgi National Park, ACT, 2002 -2004

Date & Time	Habitat & Conditions	Observation
31-08-02 10.42 pm	Open mixed montane Eucalyptus woodland and tussock grassland at 1200m on Boboyan Road, opposite Brayshaw's Hut, Namadgi National Park, ACT. Clear sky and temperature of circa 5° Celsius.	Adult *T. vulpecula* (unsexed) observed for several minutes while feeding on the carcass of a road-killed medium-sized adult female eastern grey kangaroo *Macropus giganteus* that lay in the middle of the road. Carcass was fresh but had been ripped open in the abdomen by prior scavengers, possibly raptors, foxes or wild dogs. Possum appeared to be feeding on exposed flesh (and blood), but there was also evidence that it may have been feeding on partially digested plant matter in exposed and ruptured intestines.

21-06-04 6.38 pm	Open mixed montane Eucalyptus woodland and tussock grassland at 1200m on Boboyan Road, 1 km south of Brayshaw's Hut, Namadgi National Park, ACT. Partial cloud cover with patches of clear sky and temperature of circa 0° Celsius.	Adult *T. vulpecula* (unsexed) observed for about 2 minutes while feeding on the carcass of a road-killed large adult (unsexed) red-necked wallaby *Macropus rufogriseus* that lay on the side of the road. Carcass was relatively fresh but abdominal hide had been ripped away by prior scavengers such as birds and canids, and carcass had been completely eviscerated leaving hollowed out rib cage with exposed flesh. Possum was observed to feed on flesh (and pooled blood) by inserting its head and shoulders into the hollowed out rib cage / chest cavity. Ran off, after being startled by authors and camera flash (See Figure 1).
2002-2004	Open mixed montane Eucalyptus woodland along Boboyan Road, Namadgi National Park, ACT.	Several additional opportunistic observations of *T. vulpecula* hovering in vicinity of road-killed macropod carcasses, but not observed feeding.

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APPENDIX I

Figure 1. Adult common brushtail possum *Trichosurus vulpecula* scavenging on the carcass of a red-necked wallaby *Macropus rufogriseus* in far southern Namadgi National Park, ACT, at 6.38 pm on 21 June 2004.

Photo: T. Heinsohn.

opinion piece

An Australian zoologist's perspective of biodiversity research in the UK

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To an Australian zoologist, the UK is a strange place. It's a land where the sparrow is a nationally threatened species, where conserving biodiversity means holding back vegetation succession, where the black rat is declining and on the brink of being considered a threatened species, and where fox cubs appear on prime-time television nature shows as a welcome addition to spring-time gardens. Bird conservation is a high-profile business and its supporters are so numerous that farmland birds drive conservation policy at a national level. Furthermore, in the media, a change in the distributional range of a species is invariably linked to climate.

When I was invited to write an article to compare wildlife research in Wales to that in Australia, it seemed a straight-forward request. After all, Australia's high biodiversity and integrated conservation and management policies must be at the forefront of wildlife research globally. Science at the environmental level seemed well funded. Scientists and the quality of science are recognised internationally. Surely Australia could teach the British scientists a thing or two about wildlife conservation! Then again, perhaps it's wise for a younger nation to learn from the old…

I hold a position as the Biodiversity and Conservation Ecologist with the Centre of Ecology and Hydrology (CEH) in Bangor, north Wales. CEH is one of four research centres supported by the leading environmental research council of the UK: the Natural Environment Research Council (NERC) which funds and manages scientific research and training. CEH (similarly to some divisions in CSIRO in Australia) has research sites across the UK whose overall remit is to lead and drive environmental science primarily nationally but also globally. Research within CEH falls under six major themes: biodiversity, water, biogeochemistry, climate change, sustainable economies, and environmental informatics. CEH sites collaborate by using expertise available across the country, which is an advantage when considering spatial scale in any long-term ecological project. CEH also aims to establish close links with university institutions. My position is one example of integration because it is shared between CEH (as scientist) and the University of Wales in Bangor (as lecturer); indeed, both organizations share a campus. These links have been further strengthened in Bangor when NERC and the University of Wales jointly fund a £6m (*ca.* AUS$15m) building to support CEH and four schools of the university within what will become the Wales Environment Centre. Yet even with its own governance, research in Wales maintains a UK-wide perspective (Fig. 1).

Figure 1

Biodiversity research in the UK is a high-profile and well-funded field when compared to research and funding in biodiversity in Australia. The British people, and research community, find themselves within a highly-modified landscape, where funds are secured to protect what is left. Conservation measures are in place to conserve species which are common on the European continent yet are threatened in the UK (e.g. water voles, red squirrels). Interestingly, some areas such as dune ecosystems occur as islands surrounded by agricultural pasture; in some places management aims to halt succession and encourage stock grazing to maintain local biodiversity because the ecosystem has evolved with grazing pressures over recent times. The importance of disease and risk management is also on research agendas given the traffic of people and unknown produce that makes its way unannounced into this country. Importantly, a lot of research focuses on an integrated evidence-based approach for best-practice management.

In Australia, I have been fortunate enough to work as a mammal ecologist in both Victoria and later Western Australia, where I gained a PhD in the field of Zoology. I have worked on native and introduced mammals in research involving molecular genetics, population ecology, ecophysiology, conservation, wildlife disease, and island systems. I have been an employee of both government conservation agencies in both States, mining industry, and universities in Western Australia. Field trips have taken me primarily to islands including arid Barrow and Thevenard Islands off the Western Australian coast, and to subantartcic Macquarie Island in the Southern Ocean. I have also been involved with field work trapping snowshoe hares and coyotes in the Yukon of Canada, and trapping and tracking Arctic foxes in Sweden's Lappland. I have been in my current position in Wales for two years. In this essay, I wish to reflect on some of the strengths and key drivers of biodiversity research which I see as pivotal to the UK's lead in many pan-European and global initiatives, and which Australian scientists may wish to be aware of.

Research and funding

Research performance in the UK is driven by strong competition between institutions. National and international research collaboration is commonplace, and this allows the research community to enjoy the luxury of being at the forefront of European and even global research strengths.

Themed one-day workshops are commonly organised and well attended across a country where travel by car or train is easier than the distances required for travel between cities in Australia. Consequently, the opportunity to meet colleagues, and to develop strong and integrated research ideas, increases. Unfortunately, amid a high-calibre research audience, and with so many scientists about, research territories are well established. For example, in the field of mammal research it seems most of the species come with an 'expert' who draws all the funds.

Supporting this research momentum in the UK is a well-funded research community. Take one example, to seek research support for mammal conservation alone, one can apply to several Trusts (eg. Mammals Trust, People's Trust for Endangered Species, Wildlife Trust, Game Conservancy Trust, in addition to the relevant national management authorities such as Environment Agency, English Nature, Countryside Council for Wales, Scottish Natural Heritage). Opportunities also exist to work with endangered mammals overseas (eg. the Darwin Initiative) There is also a lot of opportunity for large-scale research where spatial sampling can occur at several sites not just nationally but internationally. This regional sampling is particularly encouraged if you tap into European Union (EU) funding streams such as the main research "Framework Programme". North-west Wales in particular has the advantage of being within an Objective 1 area, an EU region where the GDP is below 75% of the EU average.

There are two groups of funding bodies for ecological projects in the UK: those who support pure research (e.g.) research councils like Biotechnology and Biological Sciences Research Council (BBSRC) and NERC, and those who are willing to fund research of direct applied management or policy relevance (e.g. Department for Environment, Food and Rural Affairs). Although 'blue skies' research is funded, a lot of funding seems to be geared towards the provision of applied knowledge that provides scientifically credible answers to policy-relevant questions, now referable as 'evidence-based management'. This focus on policy makes the science support not just relevant, but transparent to a scrutinizing public audience.

These organizations also see the value (and consequent international respect) of investing in science. Here is an example[1]: Environmental research support in the UK by NERC alone (i.e. not including the other funding bodies) over 2004-2005 approximated £300m (*ca*. $AUS 700m). This research spend compares with projected research support from the ARC (combined Discovery and Linkage Programs) for the five year period of 2005-2010 of approximately $AUS 380m (equivalent to just $AUS 76m per year). In 2004, Australia's population was registered at approximately 20m compared to approximately 60m in the UK. Therefore, basic accountancy shows that research spent per capita in 2004 was $AUS4 compared to $AUS12 for the UK i.e. three times less! The figure becomes more exaggerated when BBSRC spending is incorporated into the comparison (UK spending goes up to $AUS23 per capita). The message that is unassailable is that funding per GDP, per area of land, per habitat, per species or per proportion of globally important biodiversity is far higher in the UK than in Australia.

There is a catch, of course: among a large research community of top-level scientists, research grant capture becomes more complicated to organize, and more difficult to win. For example, the EU Framework Programme requires a minimum of three member states to participate, and for large projects collaboration from *20-30 institutions* is necessary! Furthermore, NERC applications that are funded in the UK constitute approximately 10-15% of those refereed (compared with 25-30% ARC Discovery or 40-50% ARC Linkage applications), and often these must be ranked in the top 5% of all applications.

All of the main Research Councils aim to maintain an effective yet what may seem brutal, communication medium with its scientists. Research grants are first screened by an internal panel, and if deemed uncompetitive, are rejected without going out to be refereed (usually 30% rejection rate). This internal filtering is questioned by many scientists who feel that membership of the panel may lead to biases which influence what gets funded! Importantly, of those applications which are rejected, applicants are provided with a detailed summary of *why* they were rejected. This compares to the ARC response that an application has been rejected with *no* additional explanation why the decision was made (and then they wish you luck for the future!)

[1]Figures for 2004 taken from GeoHIVE, NERC, and ARC websites. GeoHive is a database for global statistics eg. human population size, economics by country, agricultural production.

Research funding is directed in part by consultation with the research community (a 'you tell us what we need to fund' approach), which includes pan-European research direction. Calls for input to shape the next stages of strategic research and development are commonplace, so there is ample opportunity for institutions or individuals to shape future research direction. Tendering for a large EU project can involve writing two rounds of pre-proposals which are used to refine the call for proposals in a process of iterative improvement. The major funding organisations recognize the advantages of a two-way approach to drive research and where to invest its funds. Directed research calls often develop into 'thematic' grant rounds similar to National Research Priority areas within the ARC. Thematic calls are, however, better funded. For example, NERC recently advertised a thematic call for projects focusing on 'Integrating post-genomics and proteomics to study host-parasite interactions in vertebrate and invertebrate animals' which in itself totaled some £2m. This is in addition to the "responsive-mode" research funding streams described above which it contributes to.

Research excellence among universities is driven by the Research Assessment Exercise (RAE), similar yet more stringent than, the Australian Research Activity Index (RAI). All Schools strive to reach a 5 or 5* RAE rating which secures them critical financial support from the national higher education funding councils over the next 7 years. Currently, the strive for excellence goes beyond standard publication of research in journals with a high impact factor. Instead, the current round of UK assessments in 2008 (considering the period 2001-2007) will focus on paper *quality* rather than *quantity*. For example, a publication in a journal with a low impact factor may be ranked (by an assessor) as high or higher than a paper published in a top-ranking journal if its citation rate (number of times the paper has been cited by other papers) is higher.

Data also exist that compare UK and Australia's research performance to the rest of the world for the year 2004 (Office of Science & Technology 2004). Each country has a distinctive research footprint (*sensu* Office of Science & Technology 2004) which can be used to graphically compare key indicators of research performance to create a 'footprint'. Three research footprints are shown in Fig. 2 for the USA, UK and Australia. The UK holds 12% of the global share of citations in research, and is ranked second to the USA. This compares to Australia's global citation rate of 2.7%, a much lower figure given that Australia's indices for 'researchers per thousand workforce' and 'publicly funded R&D' are higher than those of the UK. Data which compare citation rates for all journals combined (Data only available for all journals combined, not for specific journals) are also interesting between countries, with citations from Australia being far lower than citations originating from the USA or UK. It is clear from this comparison that Australian science has a way to go to compete with that of the USA and UK in terms of the indicators shown. What is interesting to note is that the research spend per GDP index is quite high for Australia (as is the number of researchers in the workforce). Based on the accounting conducted above showing that research spending is low for environmental science in Australia, it seems there must be a large amount spent in other research fields.

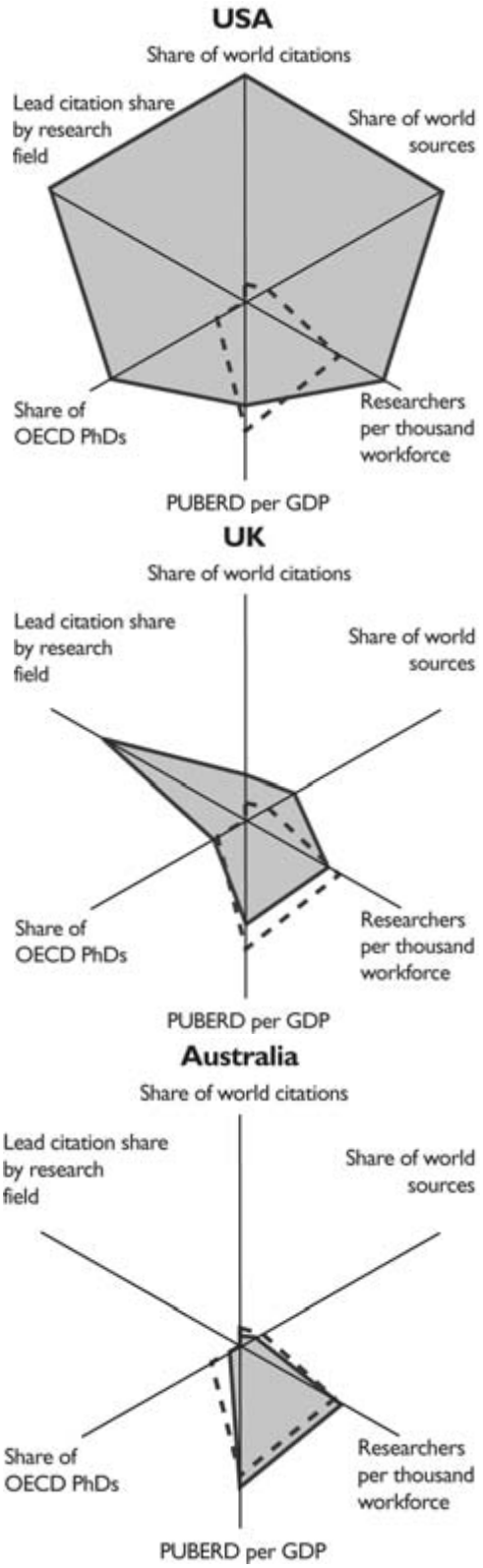

Figure 2. (a-c). Research footprint (sensu Office of Science & Technology 2004) for six research performance indicators for the USA, UK and Australia for 2004. Each axis measures a specific indicator listed, with the lowest level of performance at the origin and the highest level at the outer end of the axis. The dotted lines represent the average footprint for those countries considered in the assessment (a total of 25). 'PUBERB per GDP' is the volume of publicly funded R&D relative to GDP, and Share of OECD PhDs' refers to the number of awarded PhDs.

The 2004 report also found that there is a general correlation between the number of publications produced, and citations received. So, countries that publish more receive higher citation rates. In the biological sciences the citation:publication ratio for the UK is the world's highest (at 1.56), compared to a ratio of 0.75 for Australia. Australia's lower ratio reflects a country who publishes well but whose work does not get cited as much at the global level. This is likely to reflect the uniqueness of Australia's environment to the rest of the world. For example, seminal work on marsupial ecology is unlikely to receive as much international interest as that on vole ecology for the simple reason that the key focus is on a taxon (or taxa) with a limited global distribution compared to those which occur across the northern hemisphere. However, were publications from Australia to pitch their science at an international market (using the example above, focus on ecological paradigms rather than at the species level, and push to publish in internationally journals rather than those with an Australian focus) then there may be more appeal to reach out to an international crowd. The benefits of this approach would be to cast research findings within an international context and to make the international community appreciate the quality of the science that is undertaken within Australia.

Community group action

There is an astonishing national involvement in wildlife and conservation issues in the UK which can be difficult to imagine in Australia where apathy often seems rampant and where the Australian public often seems wilfully ignorant about the environment and their impacts upon it. Put simply, the British people love wildlife. Indeed, some become obsessed; barn owls are a welcome addition to a farm as they demonstrate to farmers that their farming practices can support biodiversity, yet many consider egg collectors and scientists to be the same group of rabid people. Local knowledge is a personal rather than an academic interest to many people. Long-term (at least 30 years) dataset exists for a variety of species and particularly, birds and insects. Records from amateur naturalists in the 18th and 19th centuries have also been useful to investigate temporal changes in certain wildlife populations. It is this time-scale that has been useful in strategically looking at trends in British wildlife and, therefore, future research direction at the policy level.

One of key environmental issues among the scientific community across the UK is climate change. There is evidence from distributions that species are moving beyond historically-known ranges, and phenological evidence that breeding is commencing earlier for several species (Crick 2004, Sparks *et al*. 2005). Importantly, this information is possible to gauge because of the existence of these long-term datasets. An important custodian for data in the UK is the Biological Records Centre. This Centre holds an impressive collection of datasets on the distribution of terrestrial and freshwater species which extend as far back as 1621 (for Sea Heath *Frankenia laevis*). Records exists for some 50 taxa, including protozoa (27,845 records), vascular plants (90,58358 records), and mammals (125,625 records). The majority of information is collected by volunteers who take part in national recording schemes such as those organized by the British Trust for Ornithology, or the Mammal Society. Take one example: nest record data for barn owls report information on clutch size, brood size, and Mayfield estimates for egg or fledging failure rates, and have been available almost annually since 1944 (British Trust for Ornithology, unpublished nest record data) (Fig. 3). Research is currently underway to understand the patterns of change in the distribution of a variety of taxa, and this is facilitated by the existence of such an impressive dataset. This is only a dream to an Australian wildlife biologist where long-term datasets with detailed species distributions rely on early explorer records (many of which are anecdotal) and traditional knowledge, and more recently, rarely extend beyond the life of a research contract of 3-5 years.

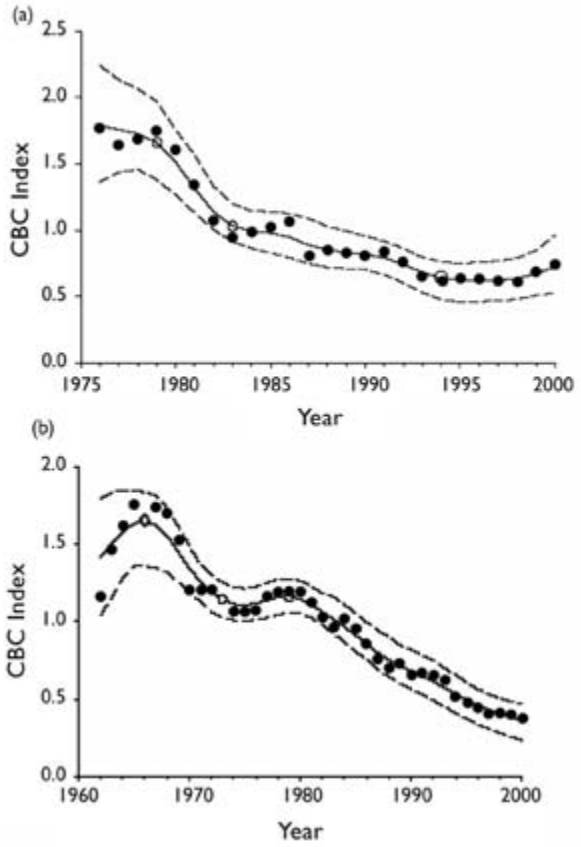

Figure 3.

Science and its communication to the public is well developed in the written media in Australia (e.g. popular magazines reporting nature science to the public such as *Nature Australia*, or *Landscope*). The UK has the BBC tradition of bringing nature via the television. Real TV has been shown to be a popular platform for nature voyeurism, and this isn't restricted to shows like Big Brother but nature shows such as 'Spring Watch' hosted by Bill Oddie (of The Goodies fame) who goes live early evenings in Spring to show the public the latest eggs to hatch from a spotted woodpecker, or the antics of badger cubs near their setts, or even to explain how to detect bats in your roof. People at home are encouraged to report the

first signs of migrants of various species (either by phone or email), or to learn about different species of moth or ladybird. Would the Australian public accept a half-hour television documentary on ladybirds?

Importantly, nation-wide (not just neighbourhood-wide) volunteer projects abound to encourage the public to take part in nature conservation and reporting: the Royal Society for the Protection of Birds is the largest membership group in the UK (with close to one million members) and it encourages encourage the public to take part in bird awareness and community action. The Tracking Mammals Partnership coordinates volunteers across the country to report mammals seen in their back gardens, or dead on the roads, as a means of tracing distribution patterns across seasons. In Wales, the 'Aren't Welsh Birds Brilliant' campaign aims to excite farmers about the importance of farmland birds given recent changes to agricultural practice (in particular, reduced stocking of farms) that aim to encourage land-for-wildlife schemes. Put simply, the public are encouraged to take part in nature conservation and monitoring, and do. It is these experiences that stimulate what I see is not just a select community of nature lovers but a whole country who seems to care about what is outside. It may be the case that a valuing of nature permeates further through British society than in Australia. But caring for nature can bring about its woes. Animal ethics is an important part of the psyche of the people in the UK, and has led to the development of the strictest animal ethics policy in the world administered by the Department of the Home Office. The high level of public concern for animal welfare is laudable, but presents particular hurdles for zoologists.

Animal ethics

Any scientist working on animals in Australia will be familiar with ethics committees and the requirement to submit a research design that aims to justify experimentation, and minimize sample size. The UK government has taken this approach further and recognizes itself as having the world's strictest (some may call it draconian) legislation dealing with experiments on animals. Animal experimentation is governed by the Home Office. Approval by the Home Office is required where an animal is used as part of a scientific 'procedure' that is essentially defined as anything invasive. This is standard practice for laboratory-based projects requiring, for example, physiological work, or research involving blood collections and surgery. Scientists who require Home Office approval to work on animals for research must apply for a personal and project license. Personal licenses are granted following the completion of a taught course comprising up to 5 modules (and up to 5 days in length at a cost of £700). Additionally, researchers must submit a detailed project license application form that specifies which procedures are to be conducted under a SMART (Specific, Measurable, Achievable, Relevant, Timely) approach. It is estimated that some Home Office project license applications can take up to six months to complete. As a zoologist who works on free-ranging animals, this can present a hurdle that more-often-than-not prevents wildlife scientists from undertaking work in the field. For example, plucking hairs from mammals by hand requires a project license (and if you don't already have one, a personal license). This must all be built into your budget. Ironically, no such licenses are required to insert transponder chips subcutaneously into animals to individually identify them, since this is considered to be 'husbandry'.

Still wish to work on animals? Like all communities, those across the UK have their extremists (Fig. 4). Bilingual signage for field sites is critical in Wales because of strong nationalist attitudes in certain areas which seem to favour linguistic militantism; signs written in English are adamantly removed from some sites unless they are bilingual. CEH buildings are security protected: entry and exit is with swipe card only. This followed a recent event where one of the offices was burnt down by an extreme animal rights group allegedly because scientists were radiotracking grouse. Yet here lies a paradox: some people become fanatical about the merits of clipping an ear or plucking some hairs from an animal to identify it, yet there are members (albeit extremists) in the community who are happy to torture badgers with snares, chase foxes with hounds, or shoot peregrine falcons.

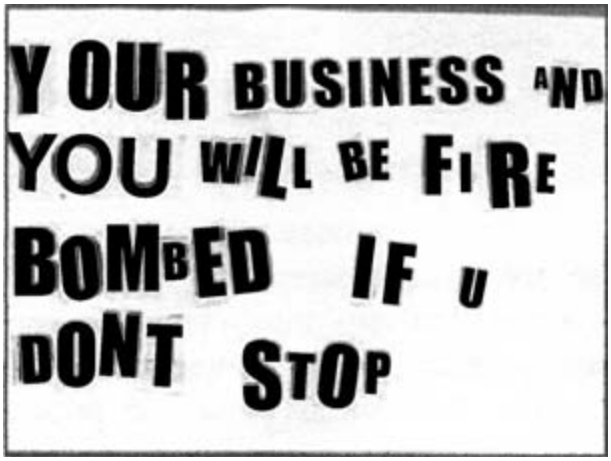

Figure 4. Animal liberation groups recently forced the closure of a farm that was breeding guinea pigs for medical research.

Conservation messages

Unlike much of Australia, people live across most of the UK landmass, people own offshore islands, and the road networks form a web across the countryside such that few places are more than a mile from a public road. Currently, approximately 77% of the rural land surface in England is farmland or open grazed land, and agriculture is therefore a key determinant of biodiversity. Nature conservation focuses on a 'gardening' mentality: create what you wish to be there. For example, roadwork agencies that damage important habitat for the nationally-threatened water vole during road construction can proceed if alternative habitat is created (yes, created!) elsewhere.

The central tenet of biodiversity conservation in the UK is to identify processes and triggers of change in the countryside by focusing upon the pressures, drivers, impacts and responses that people have on the environment. Some key environmental issues funded

across the UK include: the decline in fisheries due to over-harvesting and its impact on seabirds, declines in farmland birds attributed to agricultural intensification and habitat fragmentation, climate change and its impacts on plant and animal communities, acid deposition in the environment, and targeted species and habitat conservation and management. Within the field of mammal research alone, alien and invasive grey squirrels and American mink are causing the decline of UK red squirrels and water voles, respectively. Impressive among all this is the high degree of monitoring that is occurring to look for trends over time. Monitoring of ladybird species, mammal species, bird species, moss species, ozone levels are just a few of the examples of what is being monitored of the environment. Furthermore, a large-scale exercise called the Countryside Survey is conducted every 5 years. This survey is an audit of the British environment, and includes detailed field surveys of habitat types, hedgerows, plant and animal species and freshwater invertebrates complemented by powerful satellite imagery. The aim is to allow a deeper level of ecological understanding of change over time. Many of the sample sites were first visited in 1978 and subsequently in 1984, 1990, and 1998 providing a time series of changes in the countryside. This type of work allows the landscape to be studied, and extrapolations predicted, for the entire British land area. Any change found in one species can be correlated with other changes in environmental variables studied.

The conservation message is having an increasing impact on farmers. Traditionally, many farmers had entrenched anti-conservation attitudes and had been hostile about their land being assigned formal conservation status (such as a "Site of Special Scientific Interest" by government agencies, or volunteering to include their land into conservation schemes to maintain and improve biodiversity, but currently this is changing. Agri-environment schemes are an important mechanism for the government of Wales and England to deliver targets for specific species and habitats whilst meeting landowner socio-economic needs. Environmentally sensitive areas and the subsidy schemes which support these, such as Tir Gofal and more recently Tir Cynnal in Wales, have been the main instruments by which government has tried to influence land owners to retain, and maintain, biodiversity on their lands. Recently, a key question asked at the UK, and even the EU, level is how effective these schemes are for biodiversity conservation, and whether biodiversity indicators can be used to identify change through the landscape brought about by agricultural subsidies. Environmental repercussions are still uncertain, but they are likely to lead to a reduction in stocking rates, which has many implications for wildlife conservation.

Taken together, wildlife research in the UK pivots around monitoring the environment, and the pressures, impacts and responses that may cause change. This momentum is driven by a legacy of change through land clearing, land use, climate and greenhouse gas emissions, and more recently, to changes in agricultural practices that aim for a more sustainable conservation and economic environment. What is left is a landscape so modified by people that wildlife management strives to manage the people rather than the wildlife. Yet the cornucopia of biota in the UK is a mix of old (native) and new (exotic). Perhaps this is the 'new nature' which Tim Low (2002) sees happening within Australia, and where the Australian environment may be heading towards?

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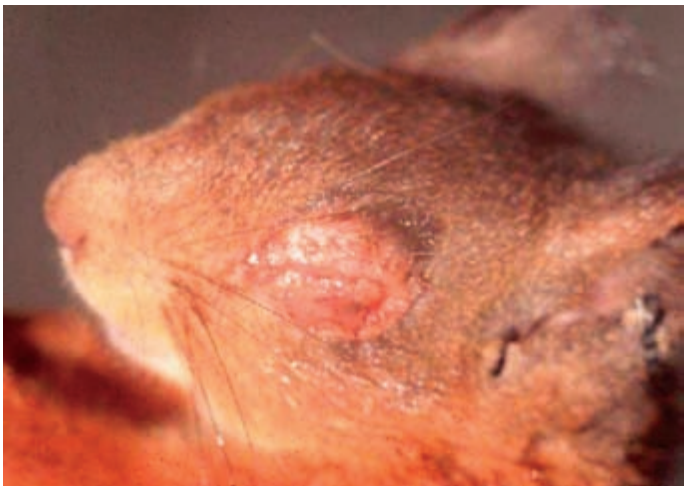
APPENDIX

American grey squirrels ***Sciurus carolinensis*** pose a serious threat to native UK red squirrels ***Sciurus vulgaris*** through resource competition and as reservoirs of a disease that is fatal to red squirrels. Efforts are underway on the island of Anglesey in northwest Wales to control grey squirrel numbers by culling, and to reintroduce red squirrels to woodlands.

Photo: Craig Shuttleworth

APPENDIX



Squirrel poxvirus is transmitted by introduced American grey squirrels to native red squirrels in the UK. The former develop immunity to the virus but the latter display clinical symptoms of infection with the virus (such as lesions to skin and eyes), and die.

Photo: Martin Cooke.

Stock grazing of sand dune meadows in Wales is an important management strategy to maintain biodiversity. The environment has evolved with grazing and removing stock will force late successional species to dominate and exclude rarer early successional species.

Photo: Laurence Jones

Water voles *Arvicola terrestris* are one of the fastest declining species in the UK, with the introduced American mink *Mustela vison* and the grazing or mowing of riverbank habitats key threats to the species. Water voles require a particular trapping protocol to ensure they are captured. Due to the shy nature of this species, traps must be set with the open door facing a vole latrine or burrow to increase the probability of capture.

Photo: Dorian Moro

Photo: Gareth Pritchard

APPENDIX

Field work in Wales requires not just stamina but careful planning for extreme weather conditions.

Photo: Dorian Moro

Barn owl *Tyto alba* nest record data report information on clutch size, brood size, and survivorship. This information is now electronically sent to the British Trust for Ornithology electronically by volunteer nest recorders and bird ringers interested in maintaining a database that surveys population trends over time. Recording commenced in 1944 and the returns from nest recorders have increased exponentially due to local interest.

Photo: Dorian Moro

The Biological Records Centre's oldest record is of Sea Heath *Frankenia Laevis*, from 1621.

Photo: Ulf Lieden

The Welsh flag with Y Ddraig Goch (the Red Dragon) sitting on the green and white background of the Tudors. The Red Dragon of Wales was first brought to Britain by the Romans approximately eighteen hundred years ago. It was initially a military standard. In 104AD in celebration of his considerable victories in the East, the Roman Emperor Trajan decreed that the standard of the Cohort (the equivalent of a modern battalion) was to be the dragon. This decree applied to Britain equally with the rest of the Roman Empire. When the Romans withdrew, the Cohort remained and with them, the symbol of the Red Dragon. When the Western Roman Empire was destroyed, so too were the Cohorts and their dragons. Within the original boundaries of the Roman Empire the Red Dragon was left as the symbol of authority only in the extreme West (Britain) and in the Eastern Roman or Byzantine Empire (but survived as a symbol in the east only until Constantinople fell to the Turks in 1465).

The Saxons from Denmark took advantage of the newly weakened state of Britain. The Saxons had, however, a preferred White Dragon. The next six hundred years saw battles and rivalry between the forces of the Celts (with their Red Dragons) and the Saxons (with their White Dragons). Around these two warring forces grew the legends of Merlin and King Arthur. Eventually a line was drawn by the Saxon King Offa of Mercia who built a Dyke separating what was Celtic Wales (and the Red Dragon) from Saxon England (and their White Dragon). Eventually the Red Dragon was adopted by the Tudors.

The flag was officially recognized by the Queen in 1959. The dragon is a symbol of a people, not of an individual. Today, Wales has its own parliament and officially is a bilingual country.